

# Case Study: Increased Productivity and Zero-Defect Soldering at BB Electronics

By Joe Vella Ottosen, BB Electronics, Horsens, Denmark

## Introduction

BB Electronics is the leading provider of EMS services in Denmark, catering to OEMs requiring high reliability and quality standards. BB Electronics specializes in the assembly of high mix, low to medium volume telecommunications and IT boards, and provides a full range of services, including: Design for Manufacturability, Surface Mount and Through-hole assembly, testing, mechanical assembly, chassis assembly, and packaging. This Case Study will focus on the steps BB took to provide their customers with a zero-defect reflow process. The features of the thermal management system will be discussed, as will instances when the system was able to prevent defects and the system's ability to reduce production costs.



Figure 1: BB Electronics Production Floor

## Implementing Thermal Management

Before acquiring the real-time thermal management system in 1997, the soldering process at BB Electronics was monitored with weekly verification profiles using a pass-through profiler, and the profiles printed out to keep a record for customer audits. The pass-through profiler was a data-logger, and the process was to run the profile, connect the data-logger to the PC, and download the profile. There were several problems with this method:

1. Often the download was unsuccessful, or the data-logger got too hot and lost all the data. When this occurred, another profile had to be run.
2. Using a product profiler is time-consuming and often results in production downtime.
3. Each profile run is the equivalent of a snapshot taken with a still camera, and the oven user is forced to assume that the oven is not changing in between "snapshots." These "snapshots" will rarely catch an intermittent problem in the oven.
4. If regular profiling uncovers a problem, there is no way to tell how many products have been affected. All production between the first bad profile and the last good profile becomes suspect.

BB Electronics acquired a SlimKIC real-time profiler and the KIC Prophet System in 1997. These acquisitions led to significant improvements in the soldering process. The weekly pass-through profiles for process verification were eliminated, oven downtime reduced, and throughput increased. It previously took four or five profiles to get a new profile dialed in, which resulted in over an hour of lost production time. With the new system, a single SlimKIC profile is run, the Auto-Predict tool is used to find the optimal profile, and the recommended changes to the oven are made. A second profile is run to verify the oven is setup correctly and production can be started immediately. The system is also valuable for fine-tuning the process—for example, if 5-10 more seconds of preheat is required, or 10 seconds more above 200°C, what was previously guesswork can now be done in seconds with the Prophet software. The thermal manager made it possible to network all four of our reflow ovens, and the ovens are now remotely monitored from the process engineer's desk, which helps to maximize scarce engineering resources. With the Prophet System, profiling is immediate, continuous, and paperless.

## Real-time Thermal Management

The SlimKIC is a wireless pass-through profiling unit that provides live output to the profiling software throughout the profiling operation. This wireless system speeds profile development by eliminating the need to capture profile data in the profiler's memory and then return to a desktop computer to dump the data and review the results. The SlimKIC records the product profile and verifies whether the oven is capable of soldering a board within spec. With the Auto-Predict software option, the SlimKIC can identify the optimal combination of zone setpoints and beltspeed to process a given product. The SlimKIC profiles in real-time and has capabilities that distinguish it from other pass-through profilers, but it still is limited in that only provides a "snapshot" of the essentially dynamic thermal process.

The KIC Prophet is a real-time thermal management system that continuously collects live data from the reflow process through thirty thermocouples embedded in two slim stainless steel probes that are permanently mounted in close proximity to the conveyor (See Figure 2). The probe thermocouples continuously monitor the process temperatures, taking readings as frequently as every five seconds. These temperatures are displayed as "Process Profiles" on the oven's PC screen. All data is permanently recorded to the hard drive, giving users the ability to review process data from any previous production date and time. Unlike the pass-through "snapshot", the thermal manager provides us with the equivalent of a continuous "video" record of our soldering process.

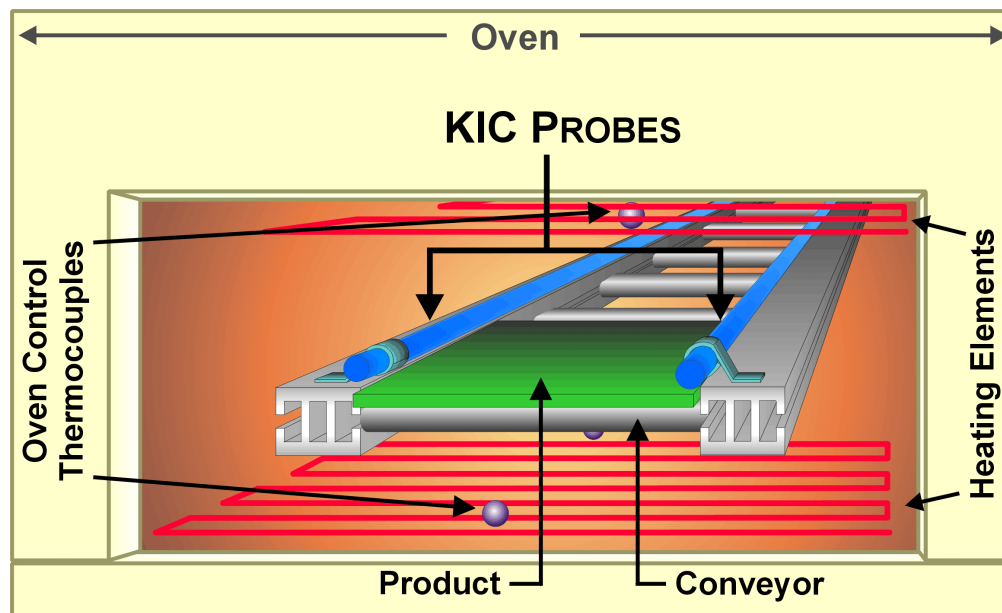


Figure 2: Probe Placement in Solder Reflow Oven

The real-time thermal manager provides a product profile for every board processed by creating a mathematical correlation between product profile, as measured by the SlimKIC, and process temperature, as measured by the real-time thermal manager thermocouple probes. This 'Virtual' product profile is calculated every 30 seconds, and Virtual Profile statistics, such as peak temperature, are also calculated and continuously updated. The real-

time thermal manager can detect critical temperature variations that the oven control thermocouples cannot, and immediately reveal these temperature drifts and their location. The instant a Virtual Profile falls outside of the pre-defined process window, the system will alarm.

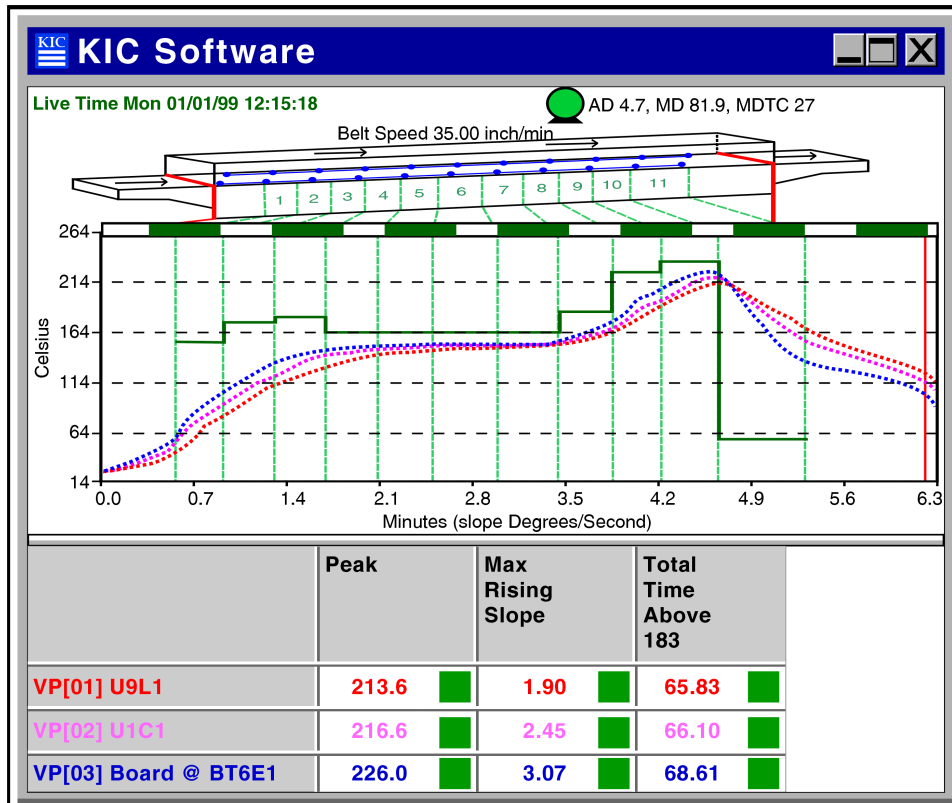


Figure 3: The Virtual Profile

## Process Development

The Auto-Predict software option is a tool capable of generating and evaluating thousands of possible oven recipes to find an optimal profile. It will then present the recommended profiles, ranked to provide the best results and widest process window. Auto-Predict has been a real timesaver at BB Electronics. In one case, a run of satellite boards had high frequency components that could only tolerate temps over 200°C for 20 seconds. In functional testing it was found that the components couldn't tolerate the current profile, which required the development of a custom profile. The Auto-Predict tool quickly found a profile that would safely solder these boards without losing any throughput.

Another recent case involved a double-sided PCB. There were no problems with the first side, but on the second side, there was oxidation on the HASL surface and the amount of solder on the pads was very thin, which caused it to oxidize very quickly. This caused many open joints, because the paste would not solder to the pads. It only took fifteen minutes to fine-tune the profile to get more heat using the automated prediction tool, and we were able to reduce opens by 50%. This was a special case where we had to increase the heat due to the poor quality of the PCB's. Because this was a double-sided board, we had to find a way to salvage the second side with the poor surface or throw many boards away. With the new profile we were able to reduce our rework by half.

## Troubleshooting Component Failures

There are times when a component on a batch of boards fails. The common reaction to this is to assume that the component got too hot and blame the reflow process. In one recent case a filter encased in a molded plastic body was hopping around on the board when exposed to the reflow process. The reel was changed, and production was fine until the next reel was loaded. This was obviously a component problem, but again it had to be proved. The component supplier did not believe the components were at fault and claimed our process must

be too hot. He visited and asked that a profile be run. He was shown the Virtual Profile, which proved that the oven was currently in control. The Prophet System was explained and demonstrated to him, and then he was shown the history files which established that the process had been in control for the entire production run. Only after the thermal process had been eliminated as a culprit was the component examined and an air bubble found that caused it to explode during reflow.

In another case of component failure, a large number of A/D converters were failing in the functional test. The component supplier wanted a profile, which we sent him, and he could not see anything wrong. He visited the plant, and after we showed him the Prophet, admitted that thermal process was not the problem. This problem affected a run of 5000 satellite boards, which were very valuable when fully mounted.

If BB had not been able to prove their reflow process was in spec, we would have had assume the costs of reworking all those boards.

Component failures seem to occur two or three times per year, and when it happens a large number of PCB's are affected. With the thermal manager, we can immediately verify that nothing is wrong with the thermal process, and go on to locate the true cause of the problem rather than having to argue with the component supplier. Without the system, it would be difficult to verify that the oven has been stable. The only possible method would be to run a profile every hour over an extended period, which would be extremely expensive. With the Prophet, it is simple to prove the oven is the same now as it was yesterday as it was a week ago.

## Zero-defect Reflow Process

The Prophet System is also able to instantly detect and alarm equipment failures. Recently, a cooling unit failure was experienced on one of our ovens. Clogged hosing caused this, which caused the temperature in the cooling zone to increase dramatically. The oven controller did not recognize this failure and the oven continued to run, but the KIC system alarmed as soon as the profile exceeded our process limits. The operator could see from the Virtual Profile that something was wrong in the cooling section and call the supervisor. We were able to react immediately to this equipment failure and replace the hose to avoid running any defective product. The figure below shows the cooling zone profiles superimposed: solid lines show the good profile, and the dotted lines show the profile with the cooling failure.

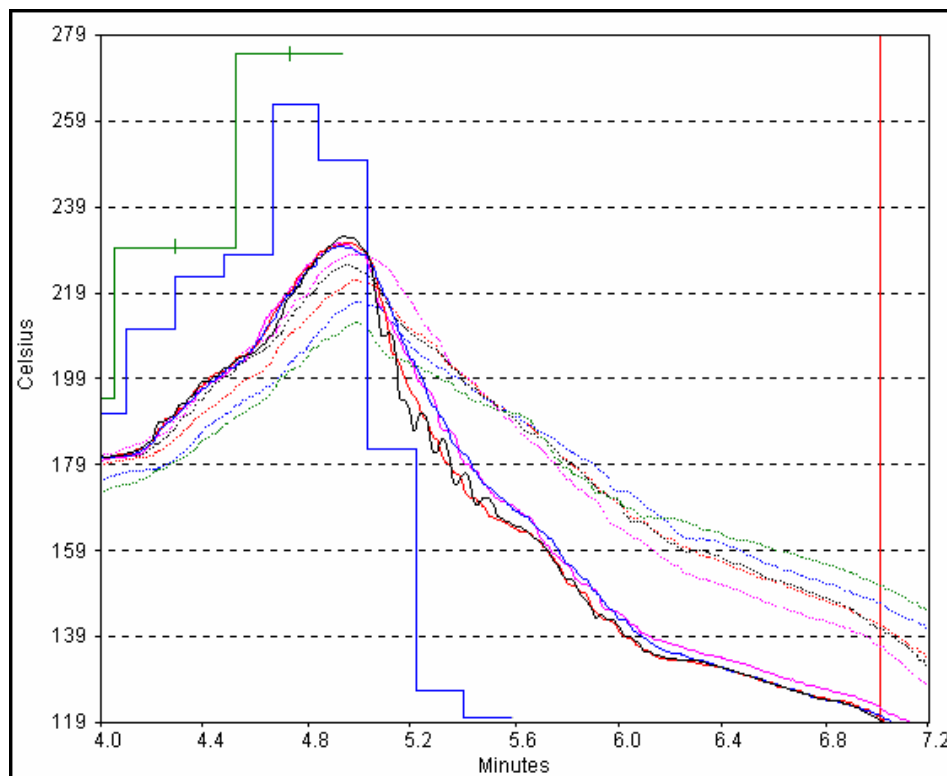


Figure 4: Superimposed Profile Detail

Another situation was the thermal manager proved its value is in the assembly of satellite amplifiers and receivers. These boards include very sensitive components, which makes a stable oven critical. These components can only tolerate a peak temperature of 220°C for 5 seconds, so the profile must be quite accurate. We used to have a high rate of failures on these boards; since we gained the ability to continuously monitor the reflow process; we have not had a single component failure.

## Customer Relations Benefits

The thermal manager is a valuable sales tool that assures customers of BB Electronics dedication to total process improvement and control. It also makes it possible for us to get contracts with customers who require that the assembly process be continuously verified. When customers come to do prototyping, we can setup the profile and the oven in about 15-20 minutes, while the customer is watching, and this gives them tremendous peace of mind about our process. The KIC Viewer, which customers can download from the KIC website, allows us to email them time and date stamped profiles whenever they want to verify our process. In addition, KIC is the keystone of our ISO 9000 documentation for the reflow process.

## Conclusion: Benefits of the Thermal Manager

The benefit that BB Electronics gets from the KIC Prophet System is total oven control. We can show our customers the ovens with KIC running on the screen and tell them that we are 100% sure that their PCB's are being processed exactly how they want them to be, every time. We estimate that we had a payback on the system in less than a year, which included man hours saved, increased production, better quality product, and less rework. We have definitely saved money by reducing defects and profiling time, and by being able to verify to our customers the profile their boards were run with. With continuous, automated, real-time thermal management from the KIC Prophet System, BB Electronics always gets high marks for its reflow process. Many EMS's do not place a high priority on the reflow process, instead focusing exclusively on the pick and place, and screen printing the paste. At the end of the day, however, if you do not solder properly, your solder joints might work in test, but they will not be reliable in the field.

The paste printers and pick and place machines one can buy today are of a very high technical standard, which allows the process to be very finely tuned. What we continue to see is a high rate of defects produced from bad components and PCB's with a bad solderability. This has shown us is that an optimal reflow profile can be the key to a successful production. At BB Electronics, we believe that our zero-defect reflow process gives us an edge that our customers appreciate.

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If you have any questions regarding this paper or any KIC products, please feel free to contact us at:

KIC • 15950 Bernardo Ctr Dr #E • San Diego, CA 92127 USA  
Phone: +1-858-673-6050 • FAX: +1-858-673-0085 • [www.kicthermal.com](http://www.kicthermal.com) • [sales@kicmail.com](mailto:sales@kicmail.com)

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